Neural control and coordination

* Introduction

- To maintain homeostasis (constant internal environment) in our body, different organs and organ system is coordinated for ex:-

During physical excercise

↓

demand of energy by cell increases

↓

Rate of breathing, heart beat, ATP formation etc increases

↓

Our different organs like heart, lunge, blood vessels, kidney etc work in cordinated way.

* Coordination

The process through two or more organs interact among themself and complement the function of one another

In our body coordination is done by two system

(1) Neural system (2) Endocrine system

- Neural system
  → By neurons
  → Fast
  → short-lived
  → point to point interaction

- Endocrine system
  → By chemical (hormone)
  → slow
  → long-lived
  → widespread in body (through blood)

- Neurons are ~~specit~~ specialised cell that can detect, recive and transmit different kind of stimuli.

- lower invertebrates have simple neural system.
  ex÷ Hydra → network of neurons
  insects have better neural system
  (Brain + ganglia + neural tissue)

- Vertebrates have complex neural system
  ex÷ human

* Human neural system

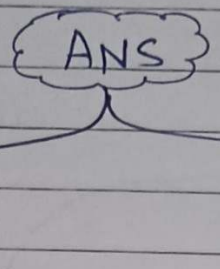
CNS
(centeral neural system)
- Brain and spinal cord
- located in center of body

PNS
(peripheral neural system)
- includes nerves (spinal + cranial nerve)
- located in periphery of body

PNS

Somatic neural system
- CNS $\xrightarrow{\text{impulse}}$ skeletal muscle
- voluntry

Autonomic neural system
- CNS ⟶ Smooth muscle
- involuntry



Sympathetic neural system

- during emergency/stress
- energy is lost

Parasympathetic neural system

- during rest
- energy is conserved

Note: Autonomic neural system is also known as visceral neural system.

* Structure of neuron

- Neuron is microscopic
- It is structural and functional unit of neural system.
- Neuron is divided into three parts

(1) Cell body / soma / cyton / perikaryon

- have nucleus, cytoplasm, cell organells
- Centriole is absent in neuron (so, it can't divide)
- Have granule like structure called Nissl's granule
  - → ribosome or RER
  - → protein synthesis

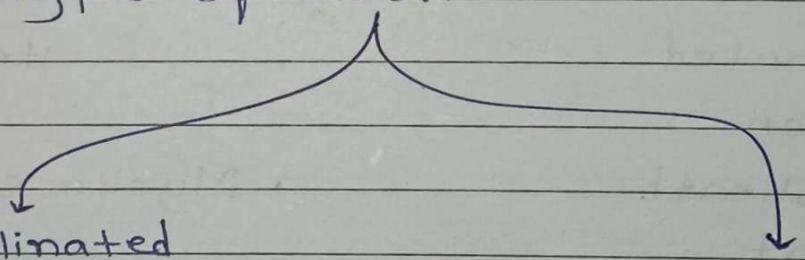
(2) Dendrits

- Short, branched, fibre arising from cell
- have nissl's granule
- It conduct nerve impulse towards centre [CENTRIPETAL CONDUCTION]

(3) Axon

- Single, long, unbranched fibre arising from cell body
- Distal part of axon is branched which form axon terminal
- Axon terminal form bulb-like structure called as synaptic knob, containing synaptic vessicle (filled with chemical, neurotransmitte
- Axon lacks nissl's granule
- It conduct nerve impulse away from centre [CENTRIFUGAL CONDUTION]

- Two types of axon



Myelinated axon → Myelin sheath is present

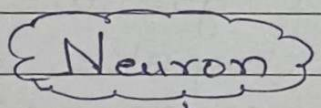
Unmyelinated axon → Myelin sheath is absent

Note:- Myelin sheath is insulated covering made of lipid which may or may not be present on axon

∴ Myelin sheath is formed by
(i) schwann cell (in PNS)
(ii) oligodedrocyte (in CNS)

· Gap b/w two adjacent ~~mylein~~ myelin sheath is known as Nodes of Ranvier. It carries nerve impulse

* Types of neuron
On the basis of myelin sheath



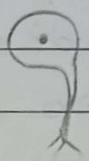
Myelinated Neuron	Unmyelinated Neuron
· Myelin sheath is present	· Myelin sheath is absent
present in cranial and spinal nerve	· present in somatic & at autonomous neural system
Conduction is fast	· Conduction is slow

Note:- In unmyelinated neuron schwann cell / oligodendrocyte is present but it doesn't form myelin sheath

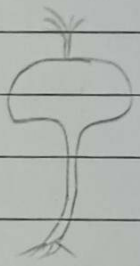
* Types of neuron (on the basis of no. of axon and dendrite)

There are three types of neuron

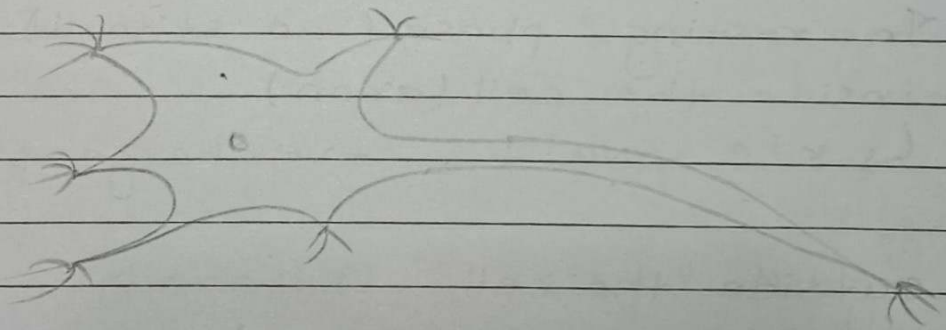
(1) Unipolar neuron
→ on axon, 0 dendrite
→ in embryonic life



(2) Bipolar neuron
→ one axon, one dendrite
→ retina of eye



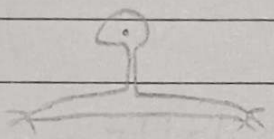
(3) Multipolar neuron
→ one axon, 2 or more dendrite



• There are two other types of neuron

- Apolar neuron
→ no axon
→ no dendrite
→ only cell body present
→ in hydra

- pseudounipolar neuron
→ One process arise from cyton that divides into two, one work as axon and other as dendrite.



* Axon
. Axolemma → plasma membrane of axon
. Axoplasm → Cytoplasm of axon

- In resting phase (no stimuli)
. inside the cell (axon)
↳ $K^+ \uparrow$, $Na^+ \downarrow$, -ve charge protein ↑

. Outside the cell
↳ $K^+ \downarrow$, $Na^+ \uparrow$, +ve charge protein ↑

→ Axolemma

$Na^+ \downarrow$ $K^+ \uparrow$ ← Axoplasm

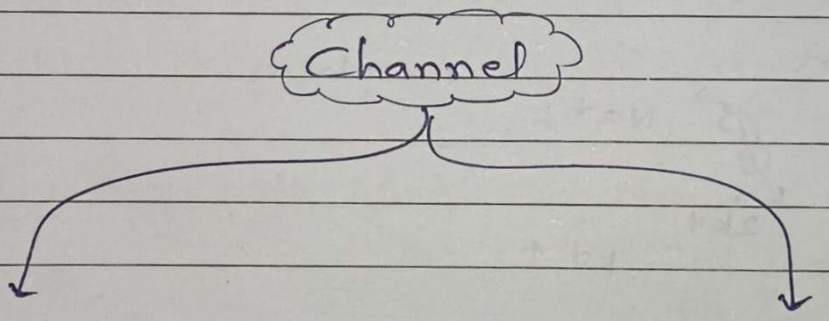
-ve charge protein ↑

ECF $Na^+ \uparrow$, $K^+ \downarrow$

+ve charge protein

- On axo-lemma protein are present which form channel and pump

* Channel
- Movement of ions from high concentration to low concentration.
(along the concentration gradient)
- No ATP required.
- passive transport.



Leaky channel
- alway ope
- two type
(i) Na^+ leaky channel
(ii) K^+ leaky channel

Voltage gated channe
- open on specific volt-age
(i) Na^+ voltage channel
(ii) K^+ voltage channel

Note:-

	open	close
Na^+ VGC	-55mv	+30mv
K^+ VGC	+30mv	start closing at -70mv

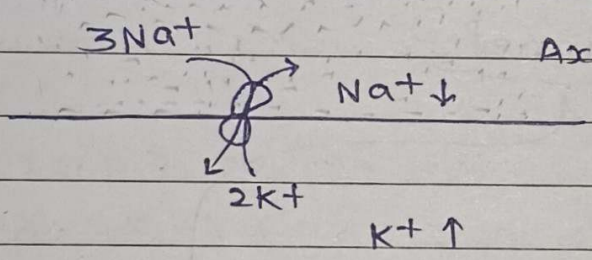
* Pump

- Movement of ions from low to high concentration (against the gradient)
- ATP required
- Active process

eg: $Na^+ - K^+$ pump

$3Na^+$ from axoplasm to ECF

$2K^+$ from ECF to axoplasm



- At resting phase [no stimuli]

(i) K^+ LC >>> Na^+ LC

(ii) axoplasm = -ve charge protein

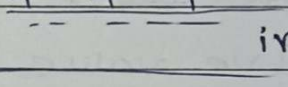
(ii) $Na^+ - K^+$ pump = 3 Na^+ out, 2 K^+ gain

Overall ~~in~~ at rest inside the cell = -ve charge and outside the cell = +ve charge

* Generation of nerve impulse
↳ 3 steps
(i) polarization / resting phase
(ii) Depolarization / exciting phase
(iii) Repolarization phase

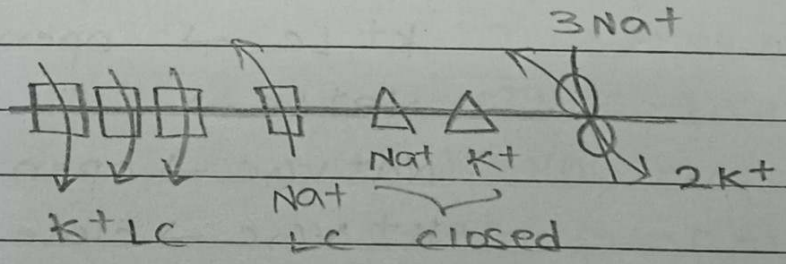
* polarization / Resting phase

- No stimulus is there, neuron is at rest
- inside cell = -ve charge
  Outside cell = +ve charge } polarize state



- Inside cell there is potential of -70mv which is known as Resting membrane potential
- During polarization :- Na^+ LC → open
  K^+ LC → open
  Na^+ VGC → close
  K^+ VGC → close
  $Na^+ - K^+$ pump → open

polarized state



* Depolarization / exiting phase

- Threshold stimulus is applied which cause change of membrane potential from -70mv to -55mv

$$\underbrace{-70mv}_{\text{resting membrane potential}} \xrightarrow{\text{threshol stimulus}} \underbrace{-55mv}_{\text{Threshold potential}}$$

- At -55mv, Na^+ VGC open causing movement of Na^+ from ECF to axoplasm. As ~~axa~~ — result -55mv changes ~~toward~~ +ve value

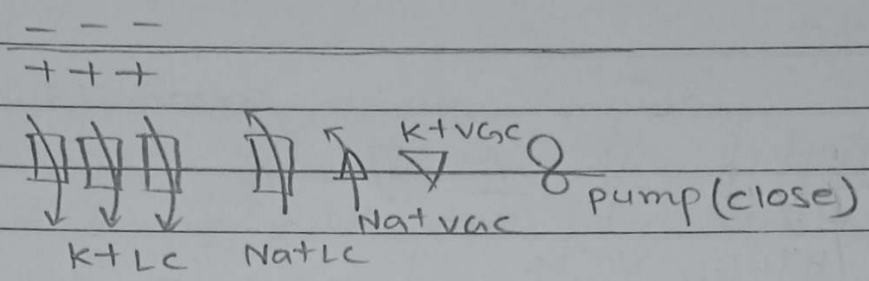
$$-55mv \rightarrow -40mv \rightarrow -10mv \rightarrow 0mv \rightarrow +30mv$$

- At +30mv, Na^+ VGC closed and action potential is generated.

- Inside = +ve (+30mv) } depolarization
  Outside = -ve

- During depolarization

  Na^+ LC → open
  K^+ LC → open
  ~~Na^+ LC →~~
  Na^+ VGC → open
  K^+ VGC → close
  $Na^+ - K^+$ pump → close



* Repolarization

inside = -ve
outside = +ve

Repolarization
↳ again ↳ polariz

- At +30mv, Na+ vgc (close), K+ vgc (open)
- Due to opening of K+ vgc, K+ moves from inside to outside.
- Due to loss of K+ ions, membrane potential will become -ve.

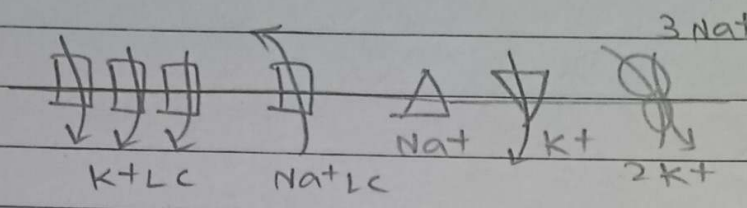
+30mv → +20mv → 0mv → -10mv → -70mv

- At -70mv, K+ vgc start closing but due to late closing of K+ vgc, more K+ ions are loss, causing hyperpolarization.

-70mv → -90mv

- During repolarization: Na+ LC → open
  K+ LC → open
  Na+ vgc → close
  K+ vgc → open
  ~~Na+~~ pump → open

+ + +
- - -



note :- −70mv ⟶ −90mv

↳ hyperpolarization due to late closing of K+ vac

−90mv ⟶ −70mv

↳ by action of channel and pump

- Conculsion :-

	polarization	Depolarization	Re-polarization
Na+ LC	✓	✓	✓
K+ LC	✓	✓	✓
Na+ vac	✗	✓	✗
K+ vac	✗	✗	✓
pump	✓	✗	✓

* Conduction of nerve impulse

Case I. site A - polarize
site B - polarize
site C - polarize
} No stimulus is there

Case II.

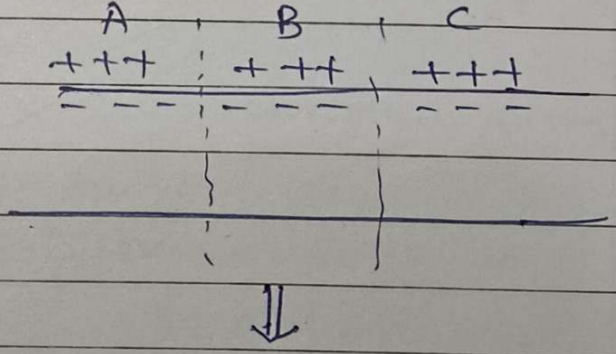
- At site A, threshold stimulus is applied
  $-70mV \longrightarrow -55mV$
- At $-55mV$, Na^+ VGC open causing depolarization at site A
- inside cell ÷ charge move from A to B
  Outside cell ÷ charge move from B to A
  } circuit is completed
- Depolarization at site A acts as single for site B

Case III

- Site B is depolarized, acting as singnal for site C
- Simultaneously site A is repolarised.

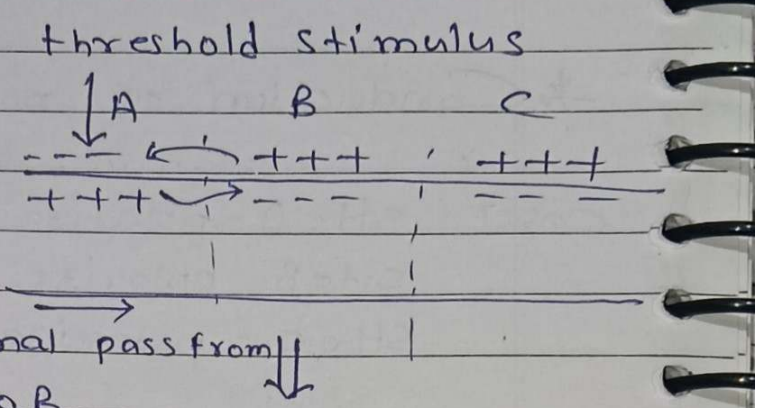
Case I.

- A = polarization
  B = polarization
  C = polarization



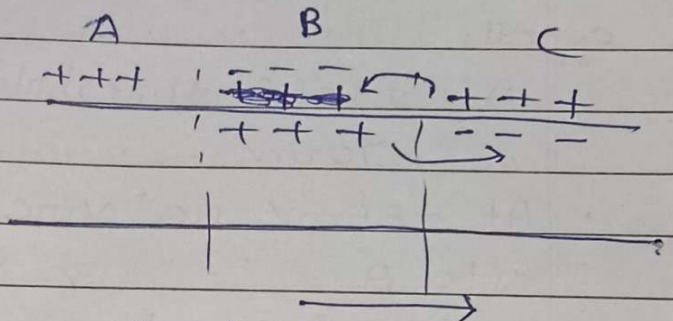
Case II.

A = depolarization
B = polarization
C = polarization



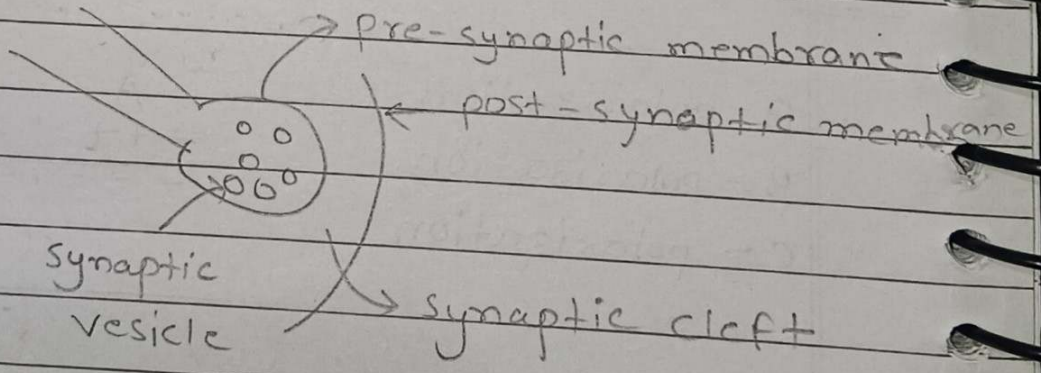
Case III.

A = Repolarization
B = Depolarization
C = polarization



* Synapse

- Junction b/w neurons
- Synapse includes :- pre-synaptic membrane
  post-synaptic membrane
  Synaptic cleft
  (gap b/w pre-synaptic neuron and post-synaptic neuron)

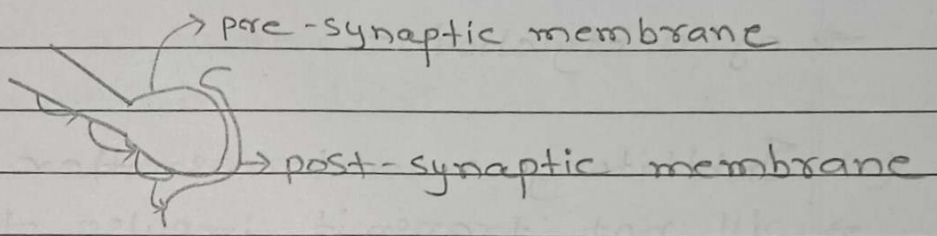


Types of synapse

There are two types of synapse

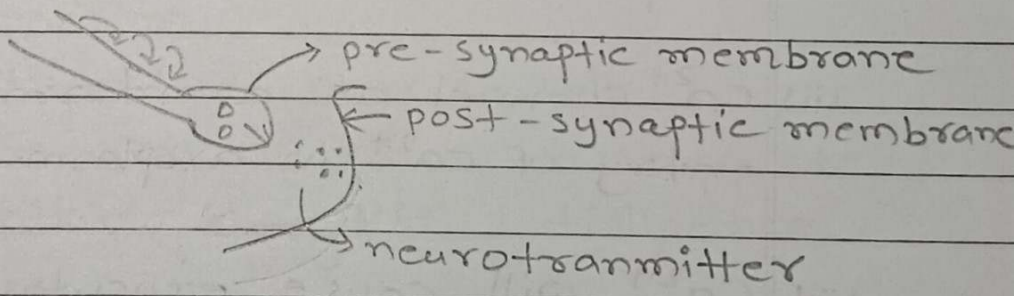
(1) Electrical synapse

- fast transmission
- rare in our body
- no need of neurotransmitter
- Both pre and post synaptic membrane are in very close proximity.
- Synaptic cleft is absent or reduced



(2) Chemical synapse

- Transmission is comparitively slow
- Commonly found in our body
- Chemical called neurotransmitter play important role.
- Synaptic cleft is present



* Neurotransmitter
Chemical that transmit message from one neuron to another (in chemical synapse)

. There are two types of neurotranmitter

(1) Excitatory neurotransmitter
→ will transmit impulse to next neuron
→ it will cause depolarization in post-synaptic neuron
→ eg: acetylcholine

(2) Inhibitory neurotransmitter.
→ will not transmit impulse to next neuron
→ it will cause hyperpolarization in post ~~ne~~ synaptic neuron
→ eg: GABA (gomma amino butyric acid)

* Message transmission across chemical synapse

(i) Impulse arrive at axon terminal

(ii) Ca^{2+} channel at axonterminal opens, causing entry of Ca^{2+} in axoplasm.

(iii) Ca^{2+} will cause exocytosis of neurotransmitter by fusing synaptic vesicle with plasma-membrane.

(iv) Neurotransmitter released in synaptic cleft and binds to its specific receptor present on post-synaptic membrane

(v) Binding of neurotransmitter cause opening of ion channel, causing depolarization (by excitatory neurotransmitter) or hyperpolarization (by inhibitory neurotransmitter) on axolemma of post-synaptic neuron

* Central neural system
. Includes brain and spinal cord

. Brain
→ Central information processing organ
→ Command and control system
→ control voluntary movement
→ regulate involuntary organs
→ thermoregulation
→ behaviour
→ Thirst and hunger
→ Endocrine function
→ circadian rhthym (24-hour cycle)
→ process information of vision, hearing etc
→ memory, emotions, thoughts, intelligence

. Weight of brain
↳ ♂ (male) ÷ 1400gm
↳ ♀ (female) ÷ 1250gm

- Brain is situated in cranium (brain box) formed by 8 flat bones. Cranium provide protection to brain.

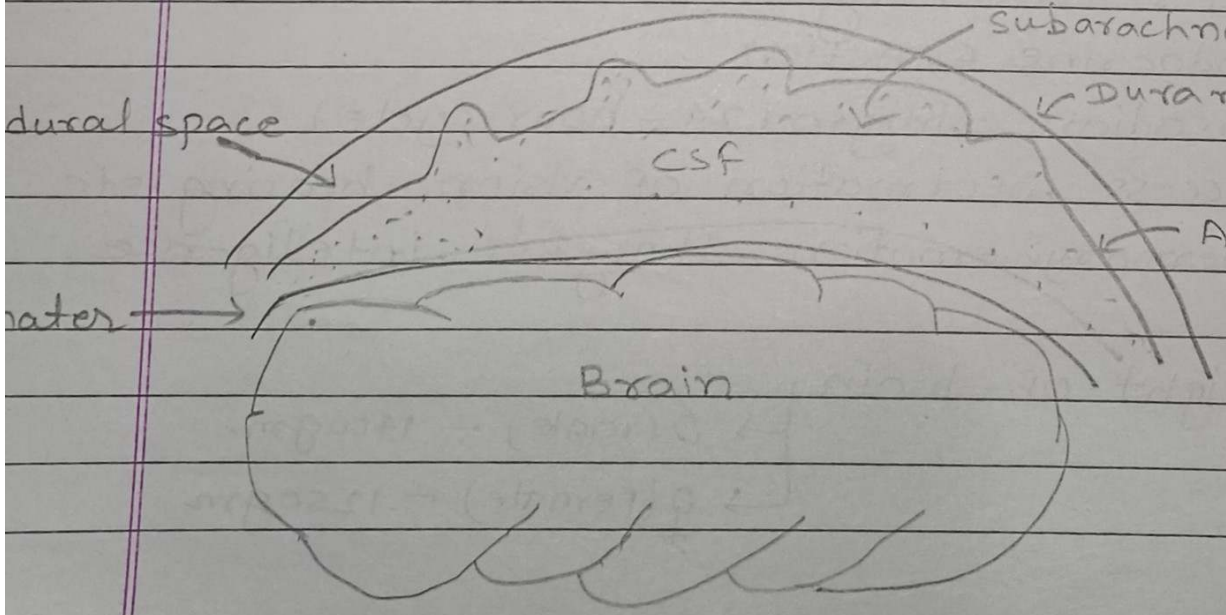
- Brain is covered by 3 covering/cranial meninges

Duramater
- outermost layer
- strong
- elastic
- thick

Arachnoid
- middle layer
- thin, delicate
- formed by arachnoid villi

piamater
- innermost layer
- thin & transpa -rent
- in contact with brain tissue

- Subdural space :- space b/w dura mater and arachnoid.
- Subarachnoid space :- space b/w arachnoid and piamater. Subarachnoid space ~~has~~ is filled with csf (cerebro spinal ~~fluid~~ fluid)



- CSF (cerebro spinal fluid)

→ clean, alkaline fluid (pH = 7.3)

→ formed in ventricle of brain

→ function : (i) proctects the brain (shock absorber)

(ii) acts as medium

(iii) provide buouancy to the brain (reducce weight of brain 1400gm → 180gm)

* Parts of brain

- Brain is divided into three parts

(1) Forebrain

→ largest part

→ forebrain is divided into three parts

(i) Cerebrum (ii) Diencephalon (iii) Olfactory lobe

(2) Midbrain

→ Smallest/marginal part

(3) Hind - brain

→ Hind brain is divided into three parts

(i) pons (ii) cerebellum (iii) Medulla/ medulla oblongata